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2017-04

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Yang , X , Kaseva , K , Keltikangas-Jarvinen , L , Pulkki-Raback , L , Hirvensalo , M , Jokela , M , Hintsanen , M , Hintsu , T , Kankaanpää , A , Telama , R , Hutri-Kahonen , N , Viikari , J S A , Raitakari , O T & Tammelin , T 2017 , ' Does Childhood Temperamental Activity Predict Physical Activity and Sedentary Behavior over a 30-Year Period? Evidence from the Young Finns Study ' , International Journal of Behavioral Medicine , vol. 24 , no. 2 , pp. 171-179 . <https://doi.org/10.1007/s12529-016-9592-5>

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<http://hdl.handle.net/10138/236697>

<https://doi.org/10.1007/s12529-016-9592-5>

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# Does Childhood Temperamental Activity Predict Physical Activity and Sedentary Behavior over a 30-Year Period? Evidence from the Young Finns Study

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Published online: 4 November 2016

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## Abstract

**Purpose** We examined associations between childhood temperamental activity, physical activity (PA), and television (TV) viewing over a 30-year period.

**Method** The participants (1220 boys and 1237 girls) were aged 3, 6, 9, and 12 years in 1980 and were followed until 2011. Temperamental activity was evaluated by participants' mothers at baseline. The PA was assessed based on maternal ratings of the child from ages 3 to 6 and via self-report age from the age of 9 across all measurements. TV viewing was assessed using self-reports taken from 2001 to 2011. The

associations between temperamental activity and the level and change of PA and TV viewing were determined using linear growth modeling stratified by gender and age group.

**Results** High temperamental activity assessed from ages 9 to 12 was associated with high levels of childhood PA in both genders, but with a steeper decline in PA levels during the first 9 years of follow-up in boys. High temperamental activity assessed from ages 3 to 6 was associated with the decline of PA from childhood to youth in girls. High childhood temperamental activity was associated with decreased levels of PA in adulthood in men, but not in women. The associations between childhood temperamental activity and TV viewing during adulthood seemed to be positive but not consistently significant in all age and gender groups.

**Conclusion** High temperamental activity may contribute to the development of a physically inactive lifestyle. More evidence is needed with regard to gender differences among participants in similar study settings.

**Keywords** Temperamental activity · Physical activity · Sedentary behavior · Follow-up

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## Introduction

Lack of physical activity (PA) and excessive sedentary time are linked to unfavorable health consequences, and they increase an individual's likelihood of developing major health problems, such as type 2 diabetes and cardiovascular disease [1–3]. Recent evidence shows that four out of five American adults do not adhere to overall PA guidelines, according to which people should engage in at least 150 min of moderate-intensity PA per week to enhance their

cardiorespiratory fitness [4]. In Finland, approximately three fourths of the adult working population does not meet the current recommendations for health-enhancing PA [5]. As a result of these concerns, health scientists have emphasized the need for designing health promotion strategies [6]. Teachers, leisure-time activity organizers, and policy-makers have also recognized the importance for encouraging lifelong PA among young people [7]. To design effective health promotion and interventions, it is essential to examine and identify factors that contribute to the development and maintenance of either physically active or sedentary lifestyles [6, 7]. Early life determinants such as temperamental traits are considered to be of especially high importance. [6].

The habits of PA and sedentary behavior begin to develop in early childhood [8–10], and this development appears to continue into adulthood [11–14]. In particular, television (TV) viewing is one of the most prevalent sedentary behaviors in adulthood [15] and excessive levels of it have been found to be more detrimental to health than computer use and driving [16]. It has been suggested that the PA of parents affect their children's PA and sedentary behavior because of model learning [11, 12]. However, the role that one's personality plays in the development of PA and sedentary behavior is less known. In adults, high levels of extroversion have been associated with higher PA, while high levels of neuroticism have been associated with lower PA [13, 14, 17]. Only few studies have focused on children's temperament and PA [6, 18].

Childhood temperament might be relevant for the development of PA. Temperament traits are biologically based, partly inherited dispositions or behavioral tendencies that comprise a core component of personality [19, 20]. Given that temperament appears to be stable suggests it is not modifiable and, therefore, not amenable to intervention. Temperament traits play a key role in one's reactivity and self-regulation [21], i.e., how a person approaches novel or unexpected things and situations and how a person expresses his or her emotions. Most salient temperament dimensions include emotionality, activity, and sociability [22]. Among temperament traits, activity levels might be of primary importance to the development of PA. Temperamental activity refers to motor vigor and tempo [22], i.e., to the need for moving, the amount of energy an individual uses for his or her actions, and the speed of his or her behaviors. If a child's temperamental activity is high, he or she has a constant need to move [23].

There is some evidence that suggests that a high level of temperamental activity is associated with a variety of unfavorable societal and health consequences. Children with high temperamental activity are prone to maladaptive behavior and poor educational achievement [24, 25]. In addition, a high temperamental activity in childhood has been shown to contribute to increased carotid intima media thickness, indicating a higher risk of atherosclerosis [21]. High levels of temperamental activity have been associated with symptoms of

attention-deficit/hyperactivity disorder (ADHD) [26]. Control and regulation deficiencies, which are typical of temperamentally highly active children, are regarded as one of the core symptoms of ADHD [26].

Research shows that biological factors mediate the association between high temperamental activity and the development of health risk factors. For instance, highly impulsive individuals may have a higher cortisol secretion in stressful situations [27]. Furthermore, a low resting heart rate and low parasympathetic activity are associated with poor physiological regulation, which may contribute to ADHD [26, 28]. The mechanisms between temperamental activity and PA may be related to biological factors [27]; however, the relationship of a child's temperamental activity to PA and sedentary behavior at different phases of life has not yet been studied thoroughly [6].

In summary, there may be an innate temperament trait that regulates one's need for PA. A high level of temperamental activity leads to a high need for constant movement. It has been suggested, however, that a high level of temperamental activity in childhood may increase the risk of diminished cardiovascular health in adulthood [21], although PA is known to be a protective factor for cardiovascular disease. This study examines whether or not childhood temperamental activity is associated with PA levels and changes from childhood to youth, as well as the level and change of PA and TV viewing during adulthood, stratified by gender and age group. The study was conducted over a 30-year period, using a population-based design.

## Methods

### Participants

The Young Finns Study is an ongoing, prospective, population-based study that involved six cohorts born in 1962, 1965, 1968, 1971, 1974, and 1977. When the study began in 1980, the participants were 3, 6, 9, 12, 15, and 18 years of age. They ( $N = 3596$ ) were randomly selected from five Finnish university cities with medical schools (Helsinki, Kuopio, Oulu, Tampere, and Turku), as well as from nearby communities. Follow-ups of measurements were conducted in 1983, 1986, 1989, 1992, 2001, 2007, and 2011. The ethics committees of the participating universities reviewed and approved the study protocol; the protocol was conducted according to the Helsinki Declaration and American Psychological Association standards. Informed consent was obtained from all subjects in accordance with the Helsinki Declaration [29].

The four youngest cohorts ( $N = 2457$ , 49.7 % males) were included in the present study (participants aged 3, 6, 9, and 12 years in 1980). Maternal ratings of temperamental activity were performed in 1980. A follow-up PA measurement was

carried out in 1983, 1986, 1989, 2001, 2007, and 2011. A TV-viewing measurement was only done for the 2001, 2007, and 2011 follow-ups. However, owing to the difference in PA assessments, the children were divided into two groups based on age at baseline: 3 to 6 and 9 to 12 years.

### Temperamental Activity

We assessed participants' temperamental activity using the 1980 maternal ratings, which were adopted from the Health Examination Survey [30]. Temperamental activity was determined via assessing participants' motor activity, and this assessment was made by asking the mothers to respond to the question: "Which of the following describes your child most accurately?" The four alternative responses were (1) "My child is always controlled, stays calm even in situations when most children would become restless," (2) "My child is overactive or restless only occasionally, for instance when tired," (3) "My child is continually more restless than the average child or youth," and (4) "My child is constantly moving and energetic, even restless." The ratings were based on a scale of 1 to 4, where 1 is low and 4 is very high. This temperamental activity scale is derived from the temperament scales described by Buss and Plomin [23]. The validity of the scale has been shown to be acceptable [31–33], and the scale has demonstrated a high homotypic stability over a 6-year period [25].

### Physical Activity

The PA of children from the ages of 3–6 was assessed using maternal ratings [34]. Mothers were asked questions concerning their children's outdoor playtime (hours/day), the amount of PA in play compared to others of the same age, the vigorousness of PA, the child's enjoyment of indoor/outdoor play, the child's general level of PA compared to others of the same age, the encouragement given to him or her to participate in sports, and the patterns of PA. The items were rated using a three-point scale (1 = low, 2 = moderate, and 3 = high), with the exception of the item that reflected the encouragement to engage in sports, which was rated via a two-point scale (1 = no, 2 = yes). By summing up the responses to the questions, a PA index was computed, and the scores ranged from 8 to 23 [35]. The maternal ratings scale reliability (Cronbach's  $\alpha$ ) of child PA varied from 0.57 to 0.63 in the younger group [34].

For participants aged 9 and upwards, PA was measured using a short self-report questionnaire. The questions concerned the respondents' frequency and intensity of leisure-time PA, participation in sports-club training, participation in sport competitions, and habitual way of spending leisure time as at 1980. The same questions were used with regard to 1983, 1986, and 1989. The responses to the questions were coded

into three categories (ranging from 1 to 3, with higher scores reflecting a higher level of PA), with the exception that a two-category coding was used with the item that had to do with participation in sport competitions (1 = no, 2 = yes). We created the sum of the responses (the index), and they ranged from 5 to 14 [36]. From 2001 onward, the PA questions consisted of items reflecting the frequency and intensity of PA, frequency of vigorous PA, hours spent engaged in vigorous PA, average duration of a PA session, and participation in an organized PA. The responses to the questions were coded into three categories: 1 = low; 2 = moderate; 3 = high. The index was calculated in the same way as during the years 1980 to 1989, and it ranged from 5 to 15 [35–37]. The test-retest estimates for overall PA over time indicated sufficient reliability for males (ICC = 0.75) and females (ICC = 0.71). The validity of PA was tested by showing statistically significant correlation with the indicators of exercise capacity in a subsample ( $n = 102$ ) [38] and with a 7-day pedometer study ( $n = 1853$ ) [39]. The reliability and validity of the PA index have been described in detail elsewhere [35, 38–41].

### Sedentary Behavior (TV Viewing)

Participants were asked to report how many hours on average per day they spent watching TV in 2001 and 2007 [42]. Self-reported TV viewing in 2011 was measured separately for weekdays and weekends in minutes, which were calculated as a weighted average of weekday and weekend responses [ $(5 \times \text{weekday} + 2 \times \text{weekend})/7$ ] and which were then converted into 1-hour increments prior to analysis.

### Covariates

In 1980, the PA of parents was assessed with the use of the question: "How much do you engage in physical activity per week?" (1 = every day, 2 = 2–6 times a week, 3 = once a week, 4 = 2–3 times a month, 5 = about once month, and 6 = not at all). The test-retest reliability of the parents' PA over a 3-year interval was satisfactory (ICC = 0.65). The parents' SES was determined by assessing educational levels and occupational status. The educational levels were classified as (1) low (comprehensive school); (2) intermediate (high school or vocational school); and (3) high (college/university). The occupational levels, based on the Central Statistical Office of Finland criteria, were categorized as (1) manual (e.g., builders, metal workers, cleaners, and nannies); (2) lower non-manual (e.g., civil servants, specialized workers and skilled workers); and (3) upper non-manual (e.g., administrators, managers and academics). The highest educational and occupational levels of the parents were used to define parents' SES in 1980. School performance was evaluated at 12 years by grade point averages (GPA) of all school subjects, ranging from 4 (low) to 10 (high).

**Table 1** Descriptive statistics for main variables by gender and age groups

Variable	3- and 6-year olds (1980)				9- and 12-year olds (1980)				
	Males ( <i>n</i> = 575)		Females ( <i>n</i> = 585)		Males ( <i>n</i> = 645)			Females ( <i>n</i> = 652)	
	<i>n</i>	<i>M</i> ± <i>SD</i>	<i>n</i>	<i>M</i> ± <i>SD</i>	<i>p</i> <sup>b</sup>	<i>n</i>	<i>M</i> ± <i>SD</i>	<i>n</i>	<i>M</i> ± <i>SD</i> <i>p</i> <sup>b</sup>
Baseline variable (1980)									
Temperamental activity	564	2.20 ± 0.68	579	2.09 ± 0.59	0.004	634	2.09 ± 0.59	638	1.99 ± 0.59    0.004
Parents' PA	537	2.17 ± 0.65	546	2.16 ± 0.65	0.797	546	2.11 ± 0.64	575	2.11 ± 0.68    0.992
Parents' SES	570	1.44 ± 0.66	578	1.43 ± 0.68	0.877	632	1.35 ± 0.60	640	1.37 ± 0.61    0.706
School performance (GPA)	446	7.77 ± 0.71	470	8.16 ± 0.66	<0.001	594	7.48 ± 0.72	589	7.97 ± 0.69    <0.001
PA in childhood and youth									
PA in 1980 <sup>a</sup>	575	16.54 ± 2.53	579	15.72 ± 2.35	<0.001	628	9.90 ± 1.62	631	9.03 ± 1.54    <0.001
PA in 1983	246	9.90 ± 1.52	259	8.80 ± 1.27	<0.001	542	9.67 ± 1.98	557	8.76 ± 1.66    <0.001
PA in 1986	471	9.94 ± 1.74	481	8.96 ± 1.51	<0.001	423	9.02 ± 2.16	475	8.40 ± 1.88    <0.001
PA in 1989	440	9.75 ± 2.08	474	8.95 ± 1.80	<0.001	401	8.37 ± 2.34	520	8.24 ± 1.90    0.347
PA in adulthood									
PA in 2001	347	9.31 ± 2.28	441	8.99 ± 1.81	0.032	393	8.91 ± 2.11	470	8.80 ± 1.84    0.405
PA in 2007	302	8.86 ± 2.06	376	8.99 ± 1.73	0.374	336	8.71 ± 1.87	422	8.82 ± 1.79    0.411
PA in 2011	258	9.06 ± 1.97	326	9.19 ± 1.89	0.413	299	8.85 ± 1.90	371	9.19 ± 1.96    0.027
TV viewing in adulthood									
TV in 2001	363	2.15 ± 1.21	461	2.10 ± 1.22	0.528	415	2.13 ± 1.12	503	1.92 ± 1.05    0.005
TV in 2007	308	1.86 ± 1.24	381	1.68 ± 1.15	0.052	348	1.88 ± 1.07	427	1.73 ± 1.03    0.040
TV in 2011	263	1.80 ± 1.27	329	1.61 ± 1.06	0.049	307	1.98 ± 1.12	380	1.72 ± 1.06    0.002

*M* mean, *SD* standard deviation, *PA* physical activity, *SES* socioeconomic status, *GPA* grade point average at age of 12, *TV* television

<sup>a</sup> Among 3- and 6-year olds, maternal rating of physical activity was used

<sup>b</sup> Student's *t* test for the gender differences

## Statistical Analyses

All participants' descriptive characteristics were assessed by means, and gender differences were tested using Student's *t* test. The associations between the baseline temperamental activity and measured variables were calculated using correlational tests. A linear growth curve modeling (within multilevel context) was applied in the analysis of two discrete periods of PA in childhood (1980 and 1983) and youth (1986 and 1989) and in adulthood (2001, 2007, and 2011), as well as of TV viewing in adulthood. The total sample size was used when applying linear growth curve modeling. Using data with missing information provided adequate statistical power and reduced bias in the estimation [43]. The model allowed for the estimation of an individual's level and change (slope) of PA/TV. Variation in level and slope was explained by childhood temperamental activity. At the first step, an unadjusted model (Model 1) was fitted. After that, the model was controlled for the parents' PA, parents' socioeconomic status (SES), and school performance (Model 2). The models of PA/TV-viewing in adulthood were additionally adjusted for baseline PA (Model 3).

The descriptive statistics were calculated using SPSS 20.0 for Windows (SPSS Inc., Chicago, IL), and all further analyses were conducted with the use of the Mplus statistical package (Version 7) [44].

The correlations and parameters of the models were estimated by using the full information maximum likelihood method (FIML). The data were assumed to be missing at random (MAR), i.e., absent data might be a function of observed outcomes and observed covariates. FIML uses all the available information in the dataset and produces unbiased parameter estimates under MAR assumption. In addition, robust standard errors were used to account for the non-normality of the PA and TV viewing variables. All the analyses were stratified by gender and age group.

## Results

The boys had a higher temperamental activity level than the girls at baseline in both age groups (Table 1). In childhood, youth, and young adulthood (1980 to 1989), male participants were physically more active than females. In adulthood (2001 to 2011), no differences were found



between men's and women's PA. Men watched TV more than women in adulthood. No gender differences were found regarding parents' PA and parents' SES among participants. The girls had higher GPAs compared to the boys.

In the group of children whose temperamental activity was assessed at ages 3 to 6, temperamental activity was inversely associated with school performance in girls but not with parents' SES in either gender (Table 2). Temperamental activity was positively associated with concurrent PA levels in both genders, but inverse associations were observed in girls 9 years later. Among boys, temperamental activity at ages 3 to 6 was inversely associated 27 years later with adult PA and positively associated with adult TV viewing 21 years later. In the group of children whose temperamental activity was assessed at ages 9 to 12, temperamental activity was inversely associated with school performance but not with parents' PA and SES in either gender. Temperamental activity was positively associated with PA 3 years later in boys and 6 years later in girls, but inverse associations were observed in boys 9 years later. Temperamental activity at ages 9 to 12 was inversely associated 21 years later with the PA of adult men and positively associated with women's TV viewing 21 and 27 years later.

Table 3 shows the unstandardized regression coefficients for childhood temperamental activity on level and

change (slope) for PA during the first 9 years of follow-up. Temperamental activity at ages 3 to 6 was inversely associated with the PA slope during the 9 years of follow-up with girls. No associations were found regarding the PA levels in the same group. Temperamental activity at ages 9 to 12 was positively associated with the PA levels in both genders and inversely associated with the PA slope during the 9-year follow-up with boys. These associations remained significant after adjustment for school performance, parents' PA, and parents' SES.

Temperamental activity at ages 9 to 12 was inversely associated with the PA levels in adulthood (2001 to 2011) in men only (Table 4). After adjusting for the potential covariates, the associations disappeared. After additional adjustments for baseline PA, the association remained significant.

Table 5 shows that temperamental activity from ages 3 to 6 was positively associated with the level of TV viewing in men, independent of school performance, baseline PA, parents' PA, and parents' SES. Temperamental activity from ages 9 to 12 was positively associated with the level of TV viewing in women. The association disappeared, however, after adjusting for all covariates. Childhood temperamental activity was not associated with changes to TV viewing in adulthood.

**Table 2** Correlation coefficients of baseline temperamental activity and measured variables by gender and age groups

Variable	3- and 6-year olds (1980)				9- and 12-year olds (1980)			
	Males ( <i>n</i> = 575)		Female ( <i>n</i> = 585)		Males ( <i>n</i> = 645)		Females ( <i>n</i> = 642)	
	<i>r</i>	<i>p</i> <sup>b</sup>	<i>r</i>	<i>p</i> <sup>b</sup>	<i>r</i>	<i>p</i> <sup>b</sup>	<i>r</i>	<i>p</i> <sup>b</sup>
Baseline variable (1980)								
Parents' PA	−0.09	0.054	−0.09	0.053	−0.02	0.702	0.00	0.974
Parents' SES	−0.02	0.643	−0.02	0.674	−0.04	0.316	−0.01	0.896
School performance (GPA)	−0.06	0.200	−0.10	0.018	−0.09	0.042	−0.16	<0.001
PA in childhood and youth								
PA in 1980 <sup>a</sup>	0.13	0.002	0.09	0.034	0.07	0.125	0.05	0.239
PA in 1983	0.06	0.406	−0.02	0.772	0.10	0.021	0.07	0.093
PA in 1986	0.01	0.834	0.01	0.805	0.00	0.934	0.09	0.046
PA in 1989	0.06	0.150	−0.12	0.006	−0.08	0.044	−0.01	0.932
PA in adulthood								
PA in 2001	−0.09	0.097	−0.04	0.436	−0.10	0.043	−0.05	0.295
PA in 2007	−0.12	0.041	−0.02	0.699	−0.04	0.497	−0.02	0.631
PA in 2011	−0.06	0.299	0.01	0.764	−0.01	0.873	−0.06	0.254
TV viewing in adulthood								
TV in 2001	0.11	0.018	0.02	0.732	0.02	0.732	0.09	0.058
TV in 2007	0.05	0.402	−0.03	0.570	−0.03	0.570	0.11	0.009
TV in 2011	0.05	0.425	0.02	0.688	0.02	0.688	0.04	0.363

PA physical activity, SES socioeconomic status, GPA grade point average at age of 12, TV television, *r* correlation coefficient

<sup>a</sup> Among 3- and 6-year olds, maternal rating of physical activity was used

<sup>b</sup> *p* value for significance of a correlation coefficient

**Table 3** Linear growth curve model of childhood temperamental activity (1980) in predicting level and slope of physical activity in childhood and youth (1980–1989) by gender and age groups

	Level			Slope		
	$\beta$	s.e.	$p^b$	$\beta$	s.e.	$p^b$
3- and 6-year olds <sup>a</sup>						
Males						
Model 1 <sup>c</sup>	0.05	0.14	0.740	0.02	0.03	0.606
Model 2 <sup>d</sup>	0.07	0.14	0.618	0.02	0.03	0.474
Females						
Model 1	0.09	0.10	0.392	-0.07	0.03	0.009
Model 2	0.09	0.10	0.365	-0.05	0.03	0.047
9- and 12-year olds						
Males						
Model 1	0.28	0.12	0.022	-0.05	0.02	0.015
Model 2	0.28	0.12	0.017	-0.04	0.02	0.040
Females						
Model 1	0.19	0.10	0.068	-0.01	0.02	0.680
Model 2	0.20	0.10	0.046	0.00	0.02	0.950

$\beta$  unstandardized regression coefficient, s.e. standard error

<sup>a</sup> Among 3- and 6-year olds, the models were fitted for time interval 1983–1989

<sup>b</sup>  $p$  value for significance of regression coefficient

<sup>c</sup> Unadjusted model

<sup>d</sup> Adjusted for school performance at age of 12, parents' physical activity, and parents' socioeconomic status

## Discussion

This study examined whether childhood temperamental activity was associated with PA and TV viewing over 30 years. High temperamental activity from ages 9 to 12 was associated with high levels of childhood PA in both genders but with a steeper decline in PA levels from childhood to youth in boys. High temperamental activity from ages 3 to 6 was associated with the decline in PA from childhood to youth in girls. High childhood temperamental activity was associated with decreased levels of PA in adulthood in men but not in women. The associations between childhood temperamental activity and adulthood TV viewing seem to be positive but not consistently significant in all age and gender groups. The results indicate that high temperamental activity might influence health-related behaviors from childhood to adulthood, particularly for men.

Our results are in line with previous studies of temperament and cognitive, behavioral, and health outcomes. The results show a relationship between temperamentally active boys with low PA levels in youth and adulthood and high TV viewing in adulthood and are partly consistent with previous research regarding temperamental activity and sedentary behavior [6]. Studies of temperament and PA are, however,

**Table 4** Linear growth curve model of childhood temperamental activity (1980) in predicting level and slope of physical activity in adulthood (2001–2011) by gender and age groups

	Level			Slope		
	$\beta$	s.e.	$p^a$	$\beta$	s.e.	$p^a$
3- and 6-year olds						
Males						
Model 1 <sup>b</sup>	-0.33	0.17	0.050	0.01	0.02	0.400
Model 2 <sup>c</sup>	-0.27	0.17	0.106	0.01	0.02	0.417
Model 3 <sup>d</sup>	-0.26	0.17	0.123	0.01	0.02	0.570
Females						
Model 1	-0.12	0.14	0.401	0.01	0.02	0.432
Model 2	-0.10	0.13	0.477	0.02	0.02	0.403
Model 3	-0.07	0.14	0.610	0.01	0.02	0.422
9- and 12-year olds						
Males						
Model 1	-0.36	0.18	0.045	0.03	0.02	0.138
Model 2	-0.28	0.17	0.101	0.03	0.02	0.143
Model 3	-0.37	0.16	0.019	0.04	0.02	0.076
Females						
Model 1	-0.14	0.14	0.335	0.00	0.02	0.913
Model 2	-0.11	0.14	0.455	0.00	0.02	0.932
Model 3	-0.13	0.14	0.326	0.00	0.02	0.935

$\beta$  unstandardized regression coefficient, s.e. standard error

<sup>a</sup>  $p$  value for significance of regression coefficient

<sup>b</sup> Unadjusted model

<sup>c</sup> Adjusted for school performance at age of 12, parents' physical activity, and parents' socioeconomic status

<sup>d</sup> Additionally adjusted for physical activity in 1980

relatively rare [6, 18]. Sedentary behavior has also been shown to contribute to morbidity and mortality [45]. Research shows that high temperamental activity is associated with poor school performance in adolescent girls [46] and adult atherosclerosis in women [21]. High levels of temperamental activity are also shown to be related to ADHD [47].

The mechanisms between temperamental activity and decreased levels of PA may be related to biological processes [27]. High temperamental activity may also be related to lack of behavioral control and regulation [26]. Accordingly, temperamental activity may be a vulnerability factor for the formation of total energy output [19, 20, 23]. Thus, we can carefully posit that high temperamental activity may contribute to irregular behavioral styles. This may, in turn, decrease the likelihood of developing PA habits that require more or less systematic behavioral functioning [38, 48]. Biological factors may affect these linkages.

Parents and caregivers are important socializing agents in terms of children's behavioral development at an early age [49]. Teachers and leisure-time activity leaders later become

**Table 5** Linear growth curve models of childhood temperamental activity (1980) in predicting level and slope of TV viewing in adulthood (2001–2011) by gender and age groups

	Level			Slope		
	$\beta$	<i>s.e.</i>	$p^a$	$\beta$	<i>s.e.</i>	$p^a$
3- and 6-year olds						
Males						
Model 1 <sup>b</sup>	0.17	0.08	0.036	−0.01	0.01	0.292
Model 2 <sup>c</sup>	0.17	0.08	0.034	−0.01	0.01	0.209
Model 3 <sup>d</sup>	0.19	0.08	0.019	−0.01	0.01	0.154
Females						
Model 1	0.01	0.09	0.918	0.00	0.01	0.786
Model 2	−0.04	0.09	0.672	0.00	0.01	0.995
Model 3	−0.06	0.09	0.537	0.00	0.01	0.891
9- and 12-year olds						
Males						
Model 1	0.02	0.10	0.804	0.01	0.01	0.476
Model 2	−0.02	0.10	0.874	0.01	0.01	0.546
Model 3	−0.04	0.10	0.720	0.01	0.01	0.477
Females						
Model 1	0.17	0.08	0.029	−0.01	0.01	0.582
Model 2	0.11	0.08	0.168	−0.01	0.01	0.615
Model 3	0.12	0.08	0.147	0.00	0.01	0.636

$\beta$  unstandardized regression coefficient, *s.e.* standard error

<sup>a</sup>  $p$  value for significance of regression coefficient

<sup>b</sup> Unadjusted model

<sup>c</sup> Adjusted for school performance at age of 12, parents' physical activity, and parents' socioeconomic status

<sup>d</sup> Additionally adjusted for physical activity in 1980

essential referents for school-aged children along with parents and peers [50, 51]. As children's temperamental characteristics remain relatively unchanged [22, 52], it is important that adults pay attention to the contents of sports activities and to the contexts in which the activities are performed. Evaluating different kinds of sports activities and educational settings in relation to a child's or a child group's temperamental activity levels might be useful for designing lifelong physical activities. For instance, professionals interested in the effects of child motor development on PA [6] might benefit from knowledge regarding motor activity and PA when planning exercises. Furthermore, children's age-related developmental stages should be taken into account when utilizing information on temperamental activity differences. Obtaining information from children regarding their motivation and preferences might also be beneficial. Overall, this study provided evidence for the role of temperament in lifelong, health-related behaviors that may benefit teachers, leisure-time activity organizers, health professionals, and policy-makers in designing and implementing actions that support children in

developing a physically active lifestyle. Multidisciplinary cooperation might be useful for meeting this goal.

## Limitations and Strengths

The results should be interpreted in light of certain limitations. PA was measured differently, but not objectively, between young children and youth and adults in the present study. However, the tracking correlations of PA from youth to adulthood have been shown to be parallel to the inter-age correlations assessed in youth [35], indicating that the construct of self-reported PA can be captured using slightly more distinct questions at different ages. Furthermore, the PA questionnaires did not capture all the possible domains (e.g., commuting to work, work-related PA, and domestic work). Another limitation involved the maternal ratings of children's behaviors, which might be slightly affected by the mothers' personality traits and the quality of their relationship with the children [53, 54]. However, the test-retest reliability and predictive validity of maternal ratings of child temperament were previously shown to be reasonably high [21, 33, 55]. Although the maternal ratings of temperamental activity and PA in early childhood appear to be related to each other, we cannot rule out the possibility that childhood PA might have increased children's energy expenditure, which in turn might have affected the mothers' evaluations of temperamental activity [18, 56]. Finally, the study was conducted among a predominantly homogeneous Finnish sample; thus, the results can only be cautiously generalized to other populations, especially to those with high levels of socioeconomic and ethnic differences.

The most evident strength of the study is its prospective study design, which allowed us to examine the associations concerning the children's temperament characteristics and PA and TV viewing over the course of 30 years. Linear growth curve modeling provided an appropriate framework for these assessments. In addition, the study was population-based and included a large sample size.

## Conclusions

A high temperamental activity level may contribute to the development of a physically inactive lifestyle. Understanding the role of temperamental activity in lifelong health behaviors may benefit teachers, leisure-time activity organizers, health professionals, and policy-makers. Greater understanding of temperamental activity levels and PA would help in the design and implementation of recreational activities that support the development of a physically active lifestyle from childhood to adulthood. More evidence is needed with regard to gender differences among participants in similar study settings.



**Acknowledgments** This study was financially supported by the Academy of Finland (grants no. 77841, 210283, 123621 (L.P.-R.), 258578 (M.H.), 121584, 124282), Social Insurance Institution of Finland (O.R., J.S.A.V.), Ministry of Education and Culture (X.Y., K.K.), Turku University Foundation (O.R., J.S.A.V.), Special Federal Grants for Turku University Hospital (O.R., J.S.A.V.), Research Funds of the University of Helsinki (M.H.), Juho Vainio Foundation (L.P.-R., X.Y.), Finnish Foundation of Cardiovascular Research (O.R., J.S.A.V.), Emil Aaltonen Foundation (M.H.), Finnish Medical Foundation, Finnish Cultural Foundation, Yrjö Jahnsson Foundation (O.R., J.S.A.V.), and Urheiluoipistosäätiö (K.K.).

**Compliance with Ethical Standards** All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all participants for inclusion in the study. For the retrospective study, formal consent was not required.

**Conflict of Interest** The authors declare that they have no conflict of interest.

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